Effects of early cutting and harvesting at physiological maturity on forage production and growth of dolichos (*Lablab purpureus* (L))

Abdoul-Karim Toudou Daouda[*1], Mahaman Hamissou Illo Souley[2], Sani Idi Saidou[2], and Sanoussi Atta[3]

[1]*Research Laboratory in Management and Valorization of Biodiversity in the Sahel, Faculty of Science and Techniques, Abdou Moumouni University of Niamey, Niamey, Niger*
[2] *Department of Livestock and Pastoralism, Agronomic Science Faculty, Diffa University, Niger*
[3] *Regional Center for Training and Application in Agrometeorology and Operational Hydrology (AGRHYMET), Niamey, Niger*

[*]*Corresponding author email:* abdoulkarimtoudou@gmail.com

In Niger, livestock feed is mainly based on natural pasture and crop residues. With climate change and demographic pressure, available land for grazing is becoming less; it is also becoming populated by invasive plants that are not palatable to animals, and consequently fodder deficits are being recorded in each agricultural season. This study assessed the effect of cutting and harvesting at the physiological maturity of dolichos on fodder production in the prone Sahel area, Niger. Four morphotypes of dolichos (*Lablab purpureus*) were evaluated in a randomised block design. The results indicated that there was no significant difference for biomass yield between the morphotypes at maturity (P = 0.46), but there were differences between cuttings (P = 0.018). The growth parameters (leaf area per plant, specific leaf area and leaf area index) did not vary significantly between morphotypes, but a highly significant difference was noted between the cuttings for the leaf area per plant (P = 0.0001) and the specific leaf area (P = 0.0001). The results indicated a drop in productivity after the first two cuts due to high plant mortality. The results of this study can contribute to the continuous short-term production of fodder for livestock feed in peri-urban areas of Niger.

Keywords: Dolichos, forage, yield, Niger

Niger, a Sahelian country, has an area of 1,267,000 km², three-quarters of which is desert. Its population is mostly comprised of young people and was 17,138,707 in 2012 with an annual growth rate of 3.9% (INS 2013). The population is 84% rural and survives mainly from agriculture including rearing livestock which is one of the country's main economic activities contributing more than 12% of the national GDP (INS 2014). The availability in quantity and quality of fodder is the major constraint in livestock feeding in the Sahel (Hiernaux et al. 2016). In Niger, this diet is essentially based on natural pasture and crop residues (Camara 2010). From the analysis of the fodder balance from 2000 to 2014, it appears that on average one year out of two is in deficit with the largest deficit of 16,137,329 t of dry matter recorded in 2009 (DDP/DGPIA 2015). The few enclaves left as grazing areas for animals are degraded and invaded by *Sida cordifolia*, a plant species not palatable to animals (Mahamane 2011). Because of this invasion, the fodder deficit has been chronic since 2008 (DDP/DGPIA 2015), even though there has been some required rainfall, with negative repercussions on animal productivity.

Studies on the practice and use of legume crop by-products in animal feed have been conducted in Niger. These studies show that crop residues from legumes, such as cowpea and groundnut are the most used because they are rich in nutritional value (Gomma et al. 2017; Ousseini et al. 2017). However, the yields of these two legumes are declining due to high temperatures and reduced rainfall. Climatic variability is marked in particular by the drop in rainfall leading to the decline of the herbaceous cover, the main source of food for livestock. To fill these gaps, in recent years there has been an increasing demand for fodder crops and agricultural by-products (RECA

0041–3216/2023/040308–316

2019) to adapt to the effects of climate change in the livestock sub-sector. These effects are reflected in a scarcity and food resources intended for livestock and to an inability to meet the growing needs for meat and milk of the population. To meet the high fodder demand, particularly in urban and peri-urban areas, it is imperative to find other alternatives, such as the introduction of highly productive and quality fodder crops, such as dolichos (*Lablab purpureus* (L.)) In Niger, dolichos is an underutilised fodder legume whose cultivation is limited in valley areas that are largely irrigated (Abdou et al. 2017). It has a high fodder production potential (Amodu et al. 2004) and is resistant to drought (Agishi 1983).

Very little work has been done to determine the ideal harvesting management for dolichos in arid areas as an alternative to fodder production in arid areas during dry periods when fodder availability decreases (Nyamukanza et al. 2008). This study aimed to assess the effect of early cutting and harvesting at the physiological maturity of dolichos on fodder production in the prone Sahel area, Niger.

Materials and methods

Experimental site

The trial was conducted on the experimental site of the Faculty of Science and Technology of Abdou Moumouni University in Niamey under irrigation conditions from December 2021 to April 2022. This site is located in the southern Sahelian western zone at 9°29 N; annual rainfall is between 400 – 600 mm; the relative humidity ranges between 20% (February) and 73% (August); the temperature ranges between 24°C (January) and 33°C (April) (Météo Nationale du Niger). The soil is of the leached tropical ferruginous type with a sandy texture.

Experimental design

The experimental design was a randomised block with four dolichos varieties. There were three repetitions for harvesting at maturity to assess grain and forage yield and three other repetitions for cutting at regular intervals of 45 days from the first cut at the start of pod formation. The varieties were randomly distributed in each block in 3 × 2.5 m (7.5 m^2) plots. The successive plots were spaced 2 m apart and the blocks were 4 m apart. Before sowing, the soil was ploughed and irrigated. After sowing, the plots were irrigated every 3 days during the winter period (December to February) and then every day during March and April.

Experimental materials

Four local morphotypes of dolichos were used; three of white colour and one of red colour. Seed colour characters were based on Letting et al. (2022). The white morphotypes are distinguished from each other by the shape and the presence of striations on the integuments (Figure 1). The red-colored morphotype was collected in the Maradi region, while the others were collected in the Diffa region (Figure 2).

Figure 1**:** Presentation of the different morphological characters of the seeds of the sown morphotypes. A: morphotype 1 oval in shape and red in colour with smooth integuments. B: morphotype 2 oval in shape and white in colour with striations on the integuments. C: morphotype 3 of round shape and white colour with smooth integuments. D: morphotype 4 of flattened shape and white colour with striations on the integuments

Figure 2: The eight regions of Niger: source Humanitarian Information Centre for Niger 2005

The dolichos were sown on December 4 2021, by placing two seeds per hill. After germination, seedlings were thinned to one plant per hill 2 weeks after sowing. The spacing between the plants was 30 cm with a spacing between rows of 50 cm. Sowing was done manually using a hoe. Approximately 15,000 kg/ha, (i.e., 1.50 kg/m^2 per plot) cow manure was broadcast over the soil. NPK fertiliser (15-15-15) was also applied to the soil to supply approximately 60 kg/ha.

Daily monitoring was done to determine the phenological stages of the morphotypes studied such as emergence, flowering date, date of pod filling and maturity. A stage was noted when 50% of the plants, of the same genotype in each block reached the stage. A hand hoe was used 21 days after sowing to remove weeds.

Temperature and humidity were recorded daily using a thermo hygrometer (Tinytag Ultra 2 TGU-4500 Gemini Dataloggers Ltd, Chichester, UK) installed in the shade next to the experiment. During the experiment, the average temperature was 24.7°C while the average relative humidity was 83.3% (Figure 3).

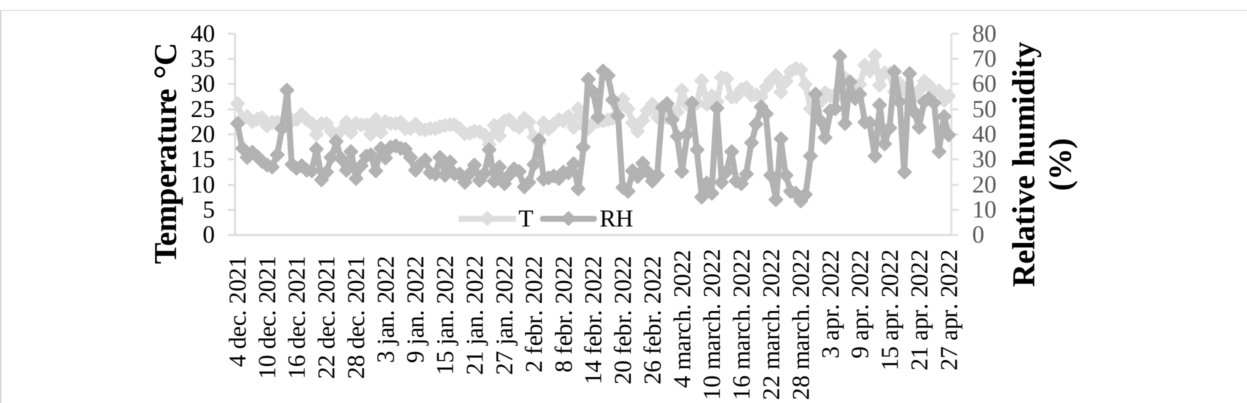


Figure 3: Change in temperature and relative humidity during the experimental period

Data collection

A total of three cuts were made, the first cut took place at pod initiation (45 days post-sowing). The other cuts followed 45-day intervals. Cutting began at 45 days post-sowing because at that time the forage material had high crude protein (Bawa et al. 2013). The third and last cut took place on April 27 2022. Limiting cuts to three is justified by the very high mortality rate (over 95%) for all morphotypes.

Forages were harvested manually with pruning shears in two rows from the middle of each plot up to 15 cm from the collar of the main stem to avoid a high cut as indicated by Watkins et al. 1951. After cutting, two plants were chosen at random to calculate the leaf area. For each plant, the total number of leaves was counted and a sub-sample of 20 leaves was taken to calculate the leaf area.

The method consisted of detaching the leaflets from the leaves and then placing them, without touching them, on a white background and then scanning them in black and white. The image is then processed with the “ImageJ” digital imaging software which, after binary conversion of the image, identifies objects and calculates their surface area in pixels. A simple conversion from the resolution of the scanned image (pixels/inches) makes it possible to know the leaf area of the plant samples.

The collected plant leaves were dried and the specific weight of the leaves was calculated from the dry weight/leaf area ratio. The total leaf area per yield square was determined by dividing the total biomass by the specific leaf weight (Mason et al. 1986).

The leaf area index (LAI) of each plot was calculated from the ratio leaf area/ground area. Specific leaf area (SLA) was calculated by leaf area/leaf dry weight ratio.

Statistical analysis

The generalised linear model procedure of the Minitab 16 software was used to analyse the morphotype, cut, and morphotype cut interaction after checking the normality of the data by Ryan Joiner's test and the equality of variance by Levene's test. The comparison of the means was done by Tukey's test at the 5% threshold. Graphs and tables were produced in Excel 2016. The significance of the correlations between the growth parameters studied was verified using the Pearson correlation test at a significance level of 5%.

Results

Impact of cutting on growth dynamics and wilt yield of morphotypes

The effects of cutting frequency on growth organisation and haulm yield of the four morphotypes are presented in Table 1. There were no significant differences between the morphotypes on the parameters measured (leaf area per plant, SLA per plant, LAI, and above ground biomass). There were significant differences between cuttings for leaf area, SLA and above ground biomass. For leaf area per plant, leaf area increased at each cut; the second cut showed the highest SLA and above ground biomass. There were no interactions between morphotype and cut.

Table 1: Effect of morphotypes and cuts on biomass Production and leaf Development

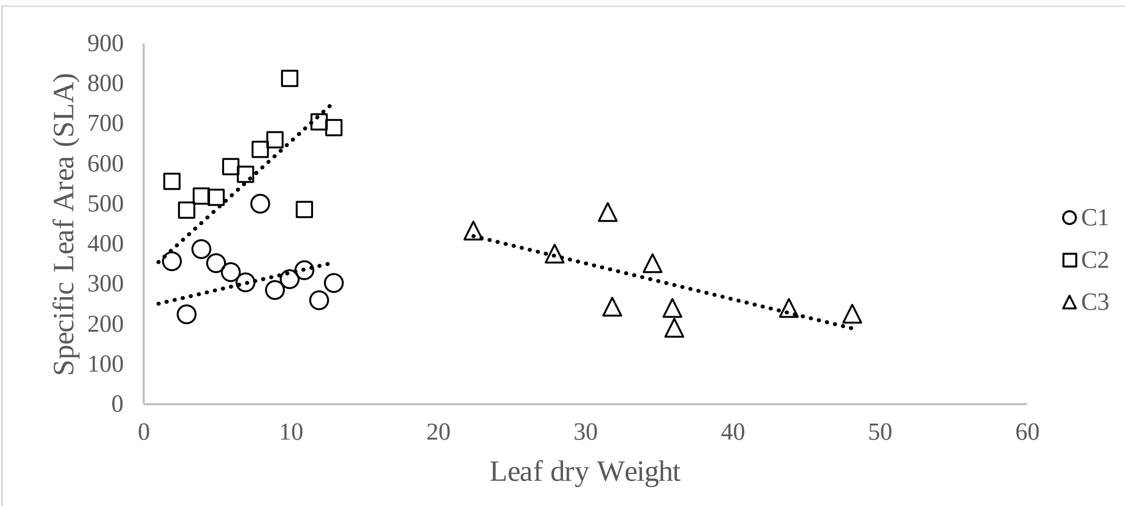
	LA/plant (cm^2)	SLA/plant (cm^2/g)	LAI/plot	Above ground biomass (kg/ha)
Morphotype 1	6056	367	2.6	678
Morphotype 2	6620	420	2.6	974
Morphotype 3	6572	424	2.5	911
Morphotype 4	7045	436	2.0	800
SE	4185	170	1.2	675
Cut1	1886[c]	328[b]	2.0	604[b]
Cut2	7629[b]	602[a]	3.1	1284[a]
Cut3	10204[a]	307[b]	2.2	635[b]
SE	2011	91	1.1	584
P values				
Morphotype	0.81ns	0.44ns	0.74ns	0.77ns
Cut	0.0001***	0.0001***	0.06ns	0.018*
Morphotype*Cut	0.56ns	0.19ns	0.59ns	0.90ns

LA: leaf area; SLA: specific leaf area; LAI: leaf area index; *, *** Significant at $P \leq 0.05$ and 0.001 respectively; ns: not significant ($P > 0.05$). Values with the same letter in the columns are not significantly different at $P \leq 0.05$

Dynamics of leaf biomass accumulation: allometric relationships

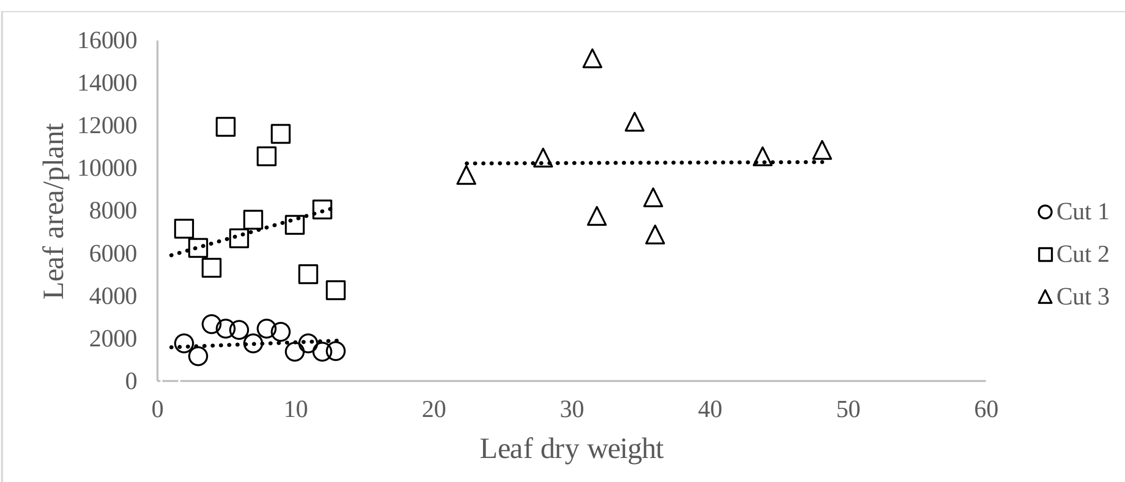
The relationship between the specific leaf area and the dry weight of the leaves (Figure 4) gave a negatively significant correlation coefficient at the (P = 0.047) for cut 3 and not significant correlations for cuts 1 and 2 with respectively P = 0.94 and 0.33. This allows us to say that there is a high production of leaf area with fewer thick leaves for cut 3.

For the relationship between leaf area and leaf dry weight (Figure 5), significant correlation coefficients were obtained for cut 1 (P = 0.009) and cut 2 (P = 0.0001) and not significant for cut 3 (P = 0.94). The study of this relationship shows us a lower production of leaf area and a production of lignified leaves for cuts 1 and 2.



Cut 1: y = 242 + 8.62x; R^2 = 0.088ns. Cut 2: y = 321 + 33.48x; R^2 = 0.09ns. Cut 3: y = 620 + 8.95x; R^2 = 0.452*.

Figure 4: The relationships between the dry weight of leaves and the specific surface area for the three cuts.



Cut 1: y = 1560 + 25.87x; R^2 = 0.52**. Cut 2: y = 5721 + 188.68x; R^2 = 0.81***. Cut 3: y = 10169 + 2.51x; R^2 = 6E-05ns.

Figure 5: The relationships between leaf dry weight and leaf area of plant for the three cuts

Evaluation of morphotype yields at physiological maturity

This section presents the results for the replicates that were harvested at maturity without any cutting. The seed and dry matter yield as well as the weight of 100 seeds of the morphotypes studied are presented in Table 2. There were no significant differences between morphotypes for dry matter, and for pod and seed weights. The average dry matter yield of the four morphotypes was 2841 kg/ha and average seed yield was 1502 kg/ha. Morphotype 1 had the highest seed weight of 24.3 g for 100 seeds.

Table 2: Seed yield and yield components of the four morphotypes studied

	Dry matter (kg/ha)	Pods (kg/ha)	Seeds (kg/ha)	100 seeds weight (g)
Morphotype 1	3463	2003	1453	24.3^{b}
Morphotype 2	2493	2321	1680	21.7^{ab}
Morphotype 3	2956	1725	1285	22.2^{b}
Morphotype 4	2452	2209	1591	22.4^{a}
SE	790.8	511.2	343.0	0.75
P values	0.46	0.53	0.55	0.014*

* Significant at the $P \leq 0.05$. Numbers with the same letter(s) in the same column are not significantly different at $P \leq 0.05$

Discussion

The study showed that there were no significant differences between genotypes for leaf growth and development, as well as for yield and yield components. After the first cut, the aerial biomass yield increased significantly, while this yield significantly decreased after the second cut. The first cut occurred on February 2 when temperatures were relatively low and the second cut on March 18 when temperatures increased. The drop in biomass yield at the third cut can be explained by the rate of regrowth, which was very low after the second cut. Everything seems to indicate that dolichos do not resist prolonged cutting according to Watkins and Severen (1951). Although dolichos is resistant to drought (Agishi 1983; Hendricksen and Minson 1985), severe defoliation can be fatal to the latter due to high temperatures (Shehu et al. 2001). However, an increase in leaf area was observed at the third cutting.

The allometric relationships for the third cut showed that there was no correlation between the leaf area and the dry weight of the leaves. In other words, the leaf area does not influence the increase in leaf biomass after the second cut. Indeed, the leaves thicken with a waxy outline, allowing plants to better withstand high temperatures.

Conclusion

The results showed that intermediate cuts of dolichos leaves can help improve forage production in the Sahel. It might be possible to go beyond five cuts by avoiding a severe cut and leaving a few leaves on the cut plant. Cultivation of dolichos as a fodder plant could help fill the fodder deficit over a period ranging from the cold season to the beginning of the dry season.

Acknowledgement

This work was financially supported by the Cowpea Square II project.

References

Abdou, M.M., S. Issa, A.D. Gomma, A. Sow, and G.J. Sawadogo. 2017. "Estimation des Rendements et de la Rentabilité

Economique de Production de Trois Cultures: Le Sorgho, Le Niébé et La Dolique à Djirataoua (Maradi–République du Niger).” *Journal of Applied Biosciences* **117:**11642–11650.

Agishi, E.C. 1983. “Forage Legumes and Pasture Development in Nigeria. In *Proceedings of Nigeria-Australia Seminar on Collaborative Agricultural Research. (Eds. Saka Nuru and Ryan JG). Shika, Nigeria* (p. 79).

Amodu, J.T., I.A. Adeyinka, and C.A.M. Lakpini. 2004. “Response of Lablab Varieties to Farmyard Manure in the Northern Guinea Savanna of Nigeria.” *Tropical Grasslands* **38(3):** 186–191.

Bawa, G.S., E.E. Abia, J.J. Omage, M.R. Hassan, and S.B. Abdu. 2013. “Nutritive Value of Dolichos Lablab (Lablab purpureus CV. Rongai) Forage cut at Different Stages of Growth on Performance of Weaned Rabbits.” *Nigerian Journal of Animal Science* 15:23–36.

Camara F.S. 2010. “Durabilité des Systèmes Pastoraux et Dynamique de la Strate Herbacée des Pâturages de la Zone Sahélienne du Niger (Afrique de l'ouest).” Thèse: Sciences de la Nature :(Alger Faculté des Sciences Biologiques Université des Sciences et Technologies - Houari Boumediene)

Direction du Développement Pastoral/Direction Générale de la Promotion et des Industries Animales (DDP/DGPIA). 2015. “Rapport de Synthèse des Résultats de la Campagne Pastorale 2015 – 2016.” Ministère de l’Élevage, Niamey, République du Niger. 37pp

Gomma, A.D., I. Chaibou, M. Banoin, and E. Schlecht. 2017. “Commercialisation et Valeur Nutritive des Fourrages Dans les Centres Urbains au Niger: Cas des Villes de Maradi et de Niamey [Forages Trade and Nutritive Value in Urban Centers in Niger: Maradi and Niamey Cities Cases].” *International Journal of Innovation and Applied Studies* **21 (3)**: 508–521.

Hendricksen, R.E. and D.J. Minson. 1985. “Lablab Purpureus - A Review.” *Herbage Abstracts* **55**:215–228.

Hiernaux, P., C. Dardel, L. Kergoat, and E. Mougin. 2016. “Desertification, Adaptation, and Resilience in the Sahel: Lessons from Long-Term Monitoring of Agroecosystems.” *The End of Desertification? Disputing Environmental Change in the Drylands.* 147–178.

Institut National de la Statistique (INS) Niger. 2013. “Présentation des Résultats Préliminaires du Quatrième (4ieme) Recensement General de la Population et de l’Habitat (RGP/H) 2012.” Ministère des Finances, Niger. 10p.

Institut National des Statistiques (INS) Niger. 2014 : *Le Niger en Chiffres*. 84 pages. 2014.

Letting, F.K., P.B. Venkataramana, and P.A. Ndakidemi. 2022. “Pre-Breeding Prospects of Lablab (Lablab purpureus (L.) Sweet) Accessions in Tanzania: Morphological Characterization and Genetic Diversity Analysis.” *Agronomy* **12 (10)**: 2272.

Mahamane, B.I. 2011. “Étude des Pratiques Associées àl’élevage de la Chèvre Rousse de Maradi chez les Femmes du Département de Madarounfa.” Master ès Sciences Agronomiques, Option Agropastoralisme, N°52, Faculté d’Agronomie Université Abdou Moumouni, Niamey, République du Niger. 48pp

Nyamukanza, C.C, P.F. Scogings, and N.W. Kunene. 2008. “Forage–Cattle Relationships in a Communally Managed Semi-Arid Savanna in Northern Zululand, South Africa.” *African Journal of Range and Forage Science* **25 (3)**: 131–140. https://doi.org/10.2989/AJRF.2008.25.3.5.602

Mason, S.C., D.E. Leihner, J.J. Vorst, and E. Salazar. 1986. “Cassava-Cowpea and Cassava-Peanut Intercropping. II. Leaf

Area Index and Dry Matter Accumulation 1." *Agronomy Journal* **78 (1):** 47–53.

Ousseini, M.M., M. Chaibou, and M. Mani. 2017. "Pratique et Utilisation des Sous-Produits de Légumineuse dans l'alimentation du Bétail à la Communauté Urbaine de Niamey: Cas de Fanes et Cosses de Niébé (Vigna Unguiculata)." *Journal of Applied Biosciences* **120**:12006–12017.

Réseau National des chambres d'Agriculture (RECA). 2019. *Recueil des Fiches Techniques.* 44 p

Shehu, Y., W.S. Alhassan, U.R. Pal, and C.J.C. Phillips. 2001. "The Effects of Sowing Date on the Growth and Nutritive Value of Lablab purpureus." *Journal of Agronomy and Crop Science* **186 (1):** 21–29.

Watkins, J. M., and M. Lewy-van Severen. 1951. "Effect of Frequency and Height of Cutting on the Yield, Stand, and Protein Content of Some Forages in E1 Salvador." *Agronomy Journal* **43:** 291–296.